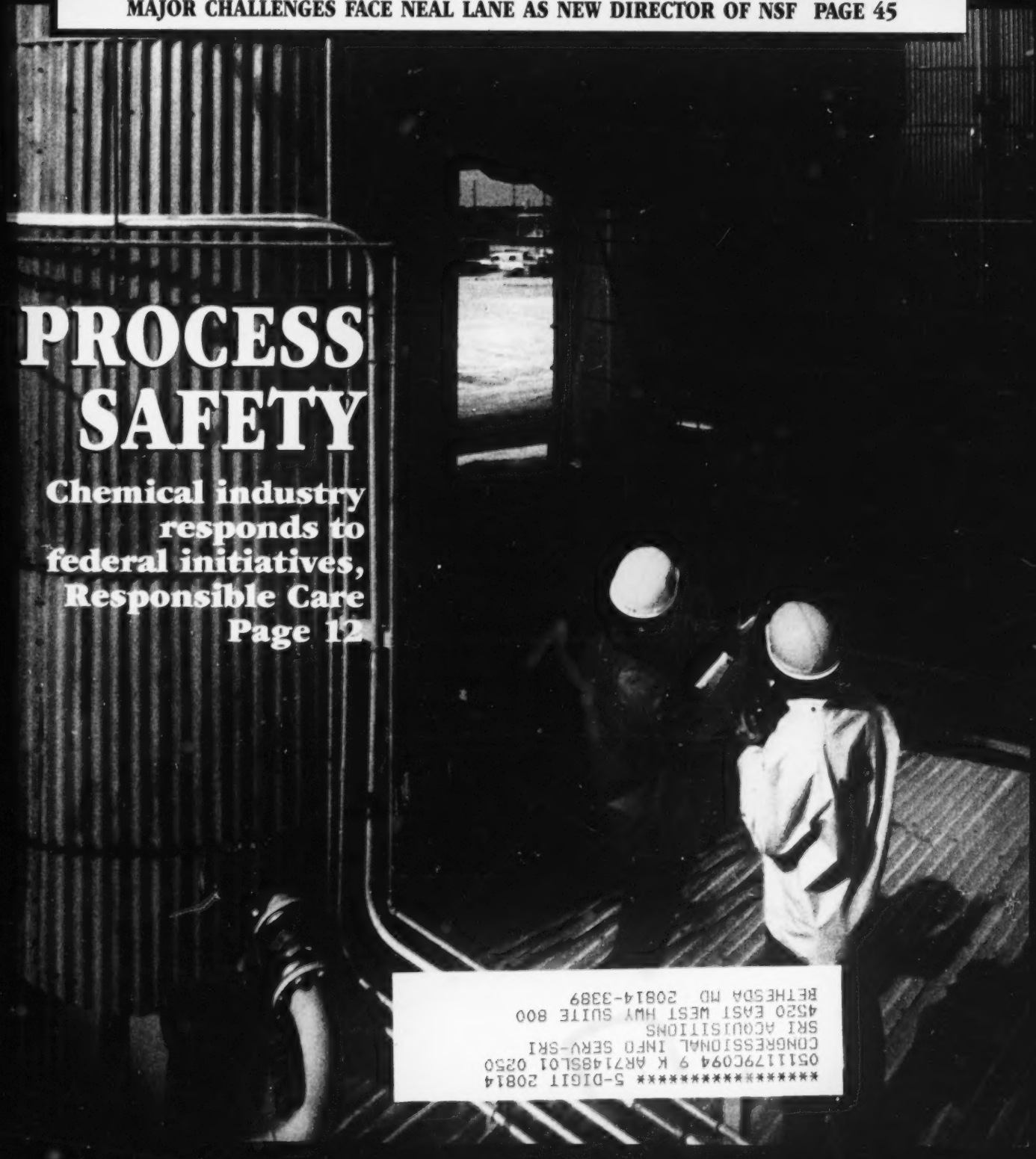
A1250-1

CHEMICAL & ENGINEERING NEWS

C&EN

NOVEMBER 29, 1993

MAJOR CHALLENGES FACE NEAL LANE AS NEW DIRECTOR OF NSF PAGE 45



PROCESS SAFETY

Chemical industry responds to federal initiatives, Responsible Care

Page 12

*********** 5-DIGIT 20814
05111796094 9 K AR7148SL01 0250
CONGRESSIONAL INFO SERV-SRI
SRI ACQUISITIONS
4520 EAST WEST HWY SUITE 800
BETHESDA MD 20814-3389

CHEMICAL & ENGINEERING NEWS

C&EN

NOVEMBER 29, 1993

NEWS OF THE WEEK

■ Near-field scanning optical microscopy has been used by Bell Labs researchers for the first time to detect fluorescence emission from single molecules and to determine their distribution and spatial orientations on a surface. **Page 6**

■ Clinton Administration unveils a new strategy that features a number of initiatives to promote export of U.S.-produced environmental technologies. **Page 7**

■ EPA and the National Weather Service plan program to monitor trends in surface UV radiation and to inform the public in daily forecasts of potential health risks from exposure to UV. **Page 7**

■ Scientists at Scripps have synthesized nanotubes consisting of stacks of cyclic polypeptides, allowing construction of nanotubes with a specific internal diameter and tailored surface properties. **Page 8**

COVER: Workers conduct plant safety check. Photo courtesy of DuPont

Volume 71, Number 48
CENEAR 71 (48) 1–72
ISSN 0009-2347

BUSINESS

New $200 million specialty chemicals company, Freedom Chemicals, is assembled by partners Harold Sorgenti and Fred Rullo, through purchases of specialty intermediates and textile chemicals operations. **Page 42**

Demand for enzymes in the U.S. is likely to increase almost 10% per year between 1992 and 1997 because of environmental and regulatory pressures, says a new report. **Page 43**

GOVERNMENT

NSF's new director, Neal Lane, faces challenges in foundation's identity crisis and low morale and in balancing Congress' demands for more emphasis on strategic research with Administration's protection of basic science. **Page 45**

SCIENCE/TECHNOLOGY

Subtle tensions at the chemistry-biology interface—as organic chemists delve into the chemistry of biological systems—emerge at a conference on the frontiers of chemistry and medicine. **Page 50**

Two new oxides—dibromine trioxide and tetranitrogen monoxide—of common elements have been prepared independently by two research groups in Germany. **Page 51**

Stacked aromatic heterocycles in the interior of DNA appear to efficiently promote electron-transfer reactions over distances of more than 40 Å, suggesting that the DNA double helix acts as a "molecular wire." **Page 52**

NEWS FOCUS

The chemical industry is under increasing pressure to step up its safety efforts, prodded by new federal initiatives and proposed rules to track safety and manage risk. Page 12

LETTERS 4
EDITOR'S PAGE 5
CONCENTRATES
Business 41
Government 44
Science/Technology 49
THE DEPARTMENTS
New Products 40
Federal Alert 48
Software/Database Update 54
ACS Comment 56
Newscripts 72

Chemical & Engineering News
1155—16th St., N.W., Washington, D.C. 20036
Editor: Michael Heylin (202) 872-4501
Managing Editor: Madeleine Jacobs
Assistant Managing Editors: James H. Krieger, Janice R. Long, Rebecca L. Rawls, Donald J. Soisson, William J. Storck
Staff Editor: Ernest L. Carpenter
Senior Correspondents: Earl V. Anderson, Lois R. Ember, Wilbert C. Lepkowski
News Editor: Richard J. Seltzer
Senior Editors: Northeast News Bureau: Stephen C. Stinson; Chicago: Joseph Haggin; London: Patricia L. Layman; Washington: Stuart A. Borman, Mairin B. Brennan, Doron Dagani, Bette Hileman, Pamela S. Zurer
Associate Editors: Jane K. Baker, Robin M. Giroux, Deborah L. Illman
Service Departments Editor: Linda Romaine Ross
Editing Services: Arlene Goldberg-Gist (Head), Rita E. Johnson (Editorial Assistant), Patricia Oates (Administrative Assistant)
News Bureaus: Northeast: (908) 906-8300 Ann M. Thayer (Head), Marc S. Reisch (Associate Editor), Rachel Eskenazi (Administrative Assistant). Houston: (713) 558-2912 Susan J. Ainsworth (Head). Washington: (202) 872-4495 David J. Hanson (Head). West Coast: (510) 653-3630 Rudy M. Baum (Head). **Foreign Bureau:** London: (01) 540-0414 Dermot A. O'Sullivan (Head)
Graphics and Production: Leroy Corcoran (Head). Barbara Fryer (Art Director). Linda Mattingly (Staff Artist). Diane Kelly (Costing)
Composition Systems Administrator: Vincent L. Parker. **Assistant:** Robin L. Braverman
Business Manager: Arthur Poulos
Circulation Director: David Schulbaum
ADVISORY BOARD: F. Peter Boer, Marvin Cassman, George Castro, Jerry Caulder, P. M. Chakrabarti, Rhetta Q. Davis, Peter B. Dervan, Marye Anne Fox, Stephen J. Lippard, Peter J. Neff, James N. Pitts Jr., Douglas J. Raber, Bassam Z. Shakhashiri, Kathleen C. Taylor, Margaret A. Tolbert, Charles S. Tuesday, Theodore R. Williams
Published by
AMERICAN CHEMICAL SOCIETY
(202) 872-4600; TDD (202) 872-4432
John Kistler Crum, Executive Director
Robert H. Marks, Director, Publications Division
PUBLISHING BOARD: Ned D. Heindel *(Chairman); Board of Directors Chairman:* Paul H. L. Walter; *President:* Helen M. Free; Paul S. Anderson, Richard L. Deming, Judith C. Giordan, Barbara J. Peterson

Subscription & Member Record Service: Send all new and renewal subscriptions with payments to: ACS, Dept. L-0011, Columbus, Ohio 43268-0011. Correspondence and telephone calls for changes of address, claims for missing issues, subscription orders, status of records and accounts should be directed to: Manager, Member & Subscriber Services, ACS, P.O. Box 3337, Columbus, Ohio 43210; (800) 333-9511 or (614) 447-3776.

For changes of address, include both old and new addresses with ZIP code numbers and mailing label from a recent issue. Allow four weeks for change to become effective. Claims for missing numbers will not be allowed if loss was due to failure of notice of change of address to be received in the time specified; if claim is dated (a) North America: more than 90 days beyond issue date, (b) all other foreign; more than one year beyond issue date; or if the reason given is "missing from files."

Subscription Rates 1993: Printed editions: nonmembers U.S. 1 yr. $110, 2 yr. $198; outside U.S. 1 yr. $148, 2 yr. $274. Air freight rates available on request. Rates above do not apply to nonmember subscribers in Japan, who must enter subscription orders with Maruzen Co. Ltd., 3-10 Nihonbashi 2-chome, Chuo-ku, Tokyo 103, Japan. Tel: (03) 272-7211. Single copies: Current $18. Rates for back issues and volumes are available from Microforms & Back Issues Office, ACS, 1155—16th St., N.W., Washington, D.C. 20036. Back and current issues available on microfilm and microfiche. Rates on request from Microform Program, ACS.

Chemical & Engineering News (ISSN 0009-2347) is published weekly except for the last week in December by the American Chemical Society at 1155—16th St., N.W., Washington, D.C. 20036. Second-class postage paid at Washington, D.C., and additional mailing offices. POSTMASTER: Send address changes to Chemical & Engineering News, Membership & Subscription Services, P.O. Box 3337, Columbus, Ohio 43210. ACS assumes no responsibility for the statements and opinions advanced by the contributors to its publications.

Advertising Management: CENTCOM LTD.
(For list of offices see page 71)
Office of Ombudsman: (800) ACS-5558, No. 5-4
© Copyright 1993, American Chemical Society
Canadian GST Reg. No. R127571347

LETTERS

Apology

We would like to apologize to anyone offended by the advertisement we ran in the Nov. 1 issue of C&EN. The "he" in the phrase "Give a Chemist what he wants for Christmas ... Chem-X Can!" was meant in the general sense to refer to both "he" and "she." The advertisement was also booked for the Dec. 6 issue, and since there is not enough time to change it, we would like to apologize in advance.

Deborah Anne Dunn
Executive Vice President
Chemical Design Inc.
Mahwah, N.J./Chipping Norton, U.K.

Noise pollution solution

Your article about the cooperation of the Dutch government and the chemical industry (C&EN, Nov. 1, page 11) interested me very much because I worked in the Netherlands for four years.

We had many contacts with the Milieudienst, the Dutch Environmental Protection Agency, which was also very concerned about noise pollution. We had experienced some severe water hammer during the startup of new facilities, and a homeowner living about 200 yards away complained about the noise. We were told not to engage in such a noisy startup between 10 PM and 6 AM. Failure to comply would not incur a fine, but would mean the cancellation of our operating permit. Needless to say, we had to find a solution to the problem to avoid the restriction, and we did, by modifying the piping and the operating procedure.

Rudolph Pick
Pompano Beach, Fla.

Space station turkey

"The demise of the SSC [Superconducting Super Collider] undoubtedly will mean the demise of other good science projects" (C&EN, Oct. 25, page 6). But that demise does not necessarily amount to a purely "sad day for science."

The space station will cost at least $2 billion per year, not counting hundreds of million of dollars for further cost overruns. No worthwhile or unique scientific missions have been identified for the space station. This turkey qualifies for immediate action under National Aeronautics & Space Administration head Daniel S. Goldin's specifications that "We have mechanisms that will terminate programs that cross certain cost growth or performance thresholds."

Robert J. Good
Professor Emeritus
State University of New York, Buffalo

Differing views on EMF

During an uproar a few months ago in my neighborhood about the dangers of high-voltage power lines, I reviewed the literature. To my surprise and dismay, I found mainly a series of epidemiological fishing expeditions and bizarre theories and speculation.

I was saddened that C&EN would dignify the subject of electromagnetic fields with such a prominent place in the magazine (Nov. 8, page 15). Members of ACS deserve better than an uncritical recitation of a hodgepodge of junk science.

Gabor B. Levy
Wilton, Conn.

It is time I expressed my appreciation to Bette Hileman for her superb articles over the years in which she has collected and ordered the scientific work on diverse subjects, each of interest to me.

I think of ones ranging from "The Great Lakes Cleanup Effort," a Special Report (C&EN, Feb. 8, 1988, page 22) to the recent "Health Effects of Electromagnetic Fields Remain Unresolved," a News Focus. Her articles alone would make *Chemical & Engineering News* worth reading.

Majorie W. Evans
Los Altos Hills, Calif.

1994 dues bill

If you have not received your 1994 dues bill or have questions about your bill or wish to charge your payment by phone, call toll free (800) 333-9511. In the Columbus, Ohio, area call (614) 447-3600. If you have questions concerning your membership, call Jean Parr, Office of Membership Development, at (202) 872-4414.

Authorization to photocopy any article for internal or personal use beyond the fair use provisions of the Copyright Act is granted by ACS to libraries and other users registered with the Copyright Clearance Center (CCC), provided that the fee of $3.00 per article copy is paid directly to CCC, 27 Congress St., Salem, Mass. 01970, USA. Copying for other than internal or personal use without express permission of ACS is prohibited. Address requests for customized bulk reprints to ACS Copyright Administrator, 1155—16th St., N.W., Washington, D.C. 20036, or call (202) 872-4367. The CCC Code for C&EN is 0009-2347/92 $3.00.

New Initiatives Take Aim at Safety Performance of Chemical Industry

Progress continues toward implementing Responsible Care code and OSHA rule; new programs are proposed to track safety, communicate risks

Deborah L. Illman, C&EN Washington

Chemical makers have always been safety conscious. By the nature of the trade, they've had to be. Over the years, the chemical industry has prided itself on its safety record.

But today the industry is under sharply increased pressure to redouble its efforts to protect both its workers and its neighbors. At the same time, further improvements in chemical process safety are proving to be laborious, costly, and difficult for the public to track.

Propelling this greater emphasis on safety are two federal initiatives. One concerns the impact of chemical releases beyond the plant fence line, the other the release of hazardous substances within the workplace. In addition, a system to track plant safety performance under the Responsible Care program of the Chemical Manufacturers Association (CMA) is being finalized and may be in place as early as next year.

The Environmental Protection Agency's proposed risk management rule, published last month in the *Federal Register*, addresses risks beyond the fence line. It is designed to prevent, detect, and respond to the release of extremely hazardous substances from chemical processes. The proposed rule would require an estimated 140,000 facilities nationwide that use listed chemicals in amounts above certain thresholds to assess and publicly disclose the potential impacts of accidental releases, including the worst case scenario. Companies would be required to document a five-year history of releases and to develop and implement prevention and emergency response programs.

The proposed EPA rule is similar to and builds upon the process safety management (PSM) standard of the Occupa-

Responsible Care Process Safety Code

In September 1990, the Process Safety Code became the third in a series of Responsible Care codes of management practices to be adopted by the Chemical Manufacturers Association. The code is designed to provide guidelnes for preventing fires, explosions, and accidental chemical releases. It identifies areas where companies can improve their safety performance, from process design through operation and routine maintenance:

MANAGEMENT LEADERSHIP

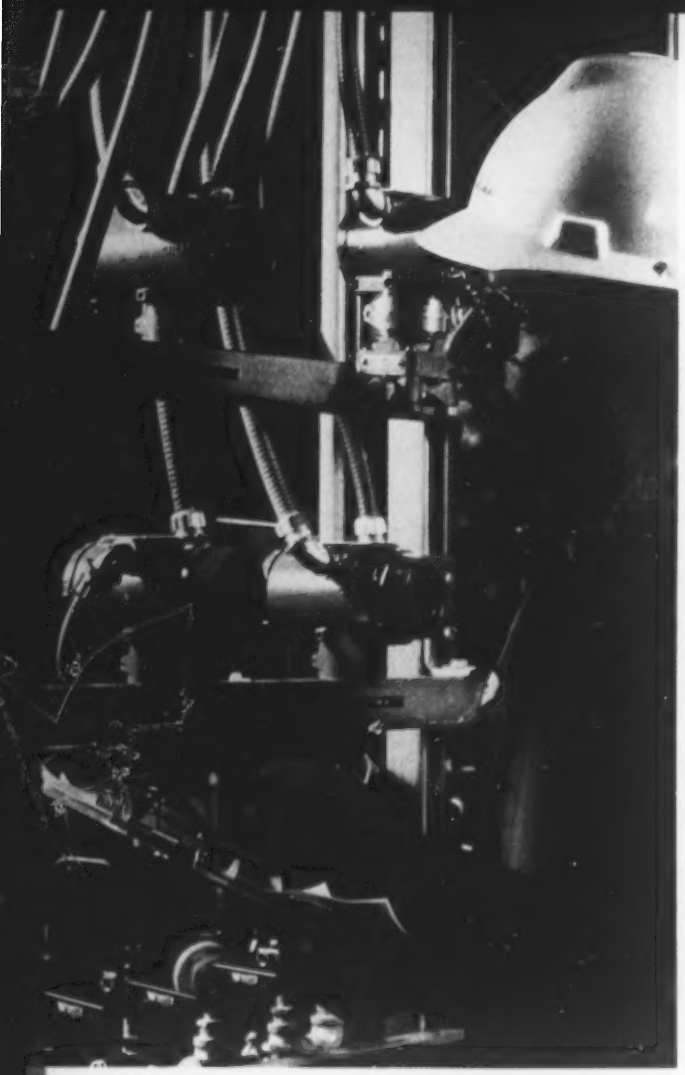
1. Leadership in achieving continuous improvement in performance, through policy, participation, communications, and resource commitments.
2. Clear accountability for performance against specific goals for continuous improvement.
3. Measurement of performance, compliance audits, and follow-through on corrective actions.
4. Investigation, reporting, corrective action, and follow-up of each incident that results or could have resulted in a fire, explosion, or accidental chemical release.
5. Sharing of relevant safety knowledge and lessons learned with industry, government, and community.
6. Use of CAER (Community Awareness & Emergency Response) process to ensure public concerns are considered in design and implementation of process safety systems.

TECHNOLOGY

7. Current, complete documentation of process design and operating parameters/procedures.
8. Current, complete documentation of hazards of materials and process technology.
9. Periodic assessment and documentation of process hazards, and implementation of actions to minimize risks associated with chemical operations, including possibility of human error.
10. Management of changes to chemical operations to maintain or enhance the safety originally designed into the facility.

FACILITIES

11. Consideration and mitigation of potential safety effects of expansions, modifications, and new sites relating to the community, the environment, and employees.
12. Facility design, construction, and maintenance using sound engineering practices.
13. Safety reviews on all new and modified facilities during design and prior to startup.
14. Documented maintenance and inspection programs that ensure facility integrity.



Technician at Henkel's Harrison, N.J., manufacturing facility checks transmitters sending information about flow, temperature, and product level to plant's computer controls.

tional Safety & Health Administration (OSHA), 29 CFR 1910.119, passed on Feb. 24, 1992, and aimed at preventing release of hazardous substances in the workplace and protecting worker health and safety. The OSHA rule is a performance-based standard that, among other things, requires companies to perform hazard assessments; develop written safety and operating procedures and provide training to employees; establish procedures to manage changes to chemical processes; conduct pre-startup safety reviews; and investigate incidents that resulted or could have resulted in accidents. OSHA believes the standard—estimated to cost more than $863 million per year for the first five years—will affect over 25,000 sites and 3 million employees nationwide.

Also last month, CMA's board of directors moved a step closer to adopting a measurement system called Prospect to track process safety performance in the association's member companies. Prospect may put new teeth in CMA's Responsible Care program, requiring members to file incident reports relating to process safety each year. The board met Oct. 25 to hammer out details and establish thresholds for incidents such as fires and explosions, releases, and injuries that would be reported. Although many in industry had expected Prospect to be approved in October for startup in 1994, the system has not yet been approved, and discussions will continue in January at CMA's next board meeting.

Responsible Care is one of several initiatives in addition to the OSHA PSM standard and proposed EPA risk management rule to be established over the past few years in response to public concerns about the impact of chemicals on safety, health, and environmental quality. A series of tragic international events in the 1970s and 1980s—at Flixborough, England; Bhopal, India; and Seveso, Italy—followed by a rash of major incidents in recent years in the U.S.—among them, the Phillips 66 explosion in Pasadena, Tex., in 1989 and the Arco Chemical, Channelview, Tex., blast in 1990—spurred the development of legislation and new programs to improve the safety performance of the chemical industry and its responsiveness to public concerns.

Responsible Care encompasses six codes of management practices covering Community Awareness & Emergency Response (CAER), Pollution Prevention, Process Safety, Employee Health & Safety, Distribution, and Product Stewardship. All CMA members—some 185—participate in the program.

In September 1990, the Process Safety Code became the third Responsible Care code of management practices to be adopted by CMA. It is aimed at preventing fires, explosions, and accidental chemical releases. According to CMA, the code is based on the principle that facilities will be safe if they are designed according to sound engineering practices; are built, operated, and maintained properly; and are

15. **Sufficient layers of protection to prevent escalation of a single failure to a catastrophic event.**

16. **Provision for control of processes/equipment during emergencies resulting from natural events or utility disruptions.**

PERSONNEL

17. **Identification of skills and knowledge necessary to perform each job.**

18. **Establishment of procedures and work practices for safe operation and maintenance.**

19. **Training for all employees to reach and maintain proficiency in safe work practices prior to work assignment and in skills needed to perform job.**

20. **Demonstration and documentation of skill proficiency prior to work assignment and periodically thereafter.**

21. **Programs to ensure that employees in safety-critical jobs are fit for duty and not compromised by external influences, including alcohol and drug abuse.**

22. **Provisions that contractors either have programs for their own employees consistent with this code or are included in the member company's program, or combination thereof.**

Source: Chemical Manufacturers Association

Tragic events of two decades spur efforts to improve process safety

INCIDENTS ABROAD:

1974 Flixborough, England
Twenty-eight deaths resulted from the explosion of a cyclohexane vapor cloud released when temporary piping failed at the Nypro facility.

1976 Seveso, Italy
Thousands affected by dioxin release from runaway reaction at Icmesa plant, owned by Hoffmann-LaRoche subsidiary.

1984 Cubatao, Brazil
Some 508 people killed in shantytown built over swamp where 700 tons of gasoline leaked from ruptured pipe and ignited.

1984 Mexico City
An explosion and fire at a liquefied petroleum gas facility in San Juanico suburb killed 542, injured more than 4,000.

1984 Bhopal, India
More than 2,000 deaths and hundreds of thousands affected by a massive leak of methyl isocyanate from Union Carbide facility due to runaway reaction after water contaminated a tank.

1986 Basel, Switzerland
A spill of 30 tons of pesticides from Sandoz plant went into the Rhine.

1987 Ras Al Juaymah, Saudi Arabia
Vapor cloud explosion at the natural gas complex reportedly killed as many as 22 and injured 15 others.

1993 Frankfurt, Germany
Explosion in polyvinyl alcohol plant killed one and injured one at Hoechst works.

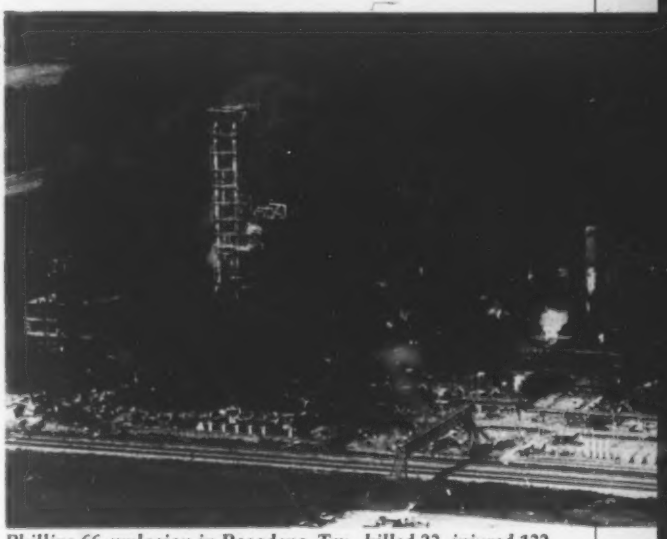
INCIDENTS IN THE U.S.:

1985 Institute, W.Va.
Vapor cloud of aldicarb oxime and methylene chloride from a Union Carbide plant injured 135.

1987 Texas City, Tex.
Vapor cloud of hydrofluoric acid from Marathon Oil refinery drifted through community; 1,000 received medical treatment.

1988 Henderson, Nev.
Ammonium perchlorate explosion at Pepcon killed two and injured 350.

Houston Chronicle photo



Phillips 66 explosion in Pasadena, Tex., killed 23, injured 132.

1989 Pasadena, Tex.
Cloud of ethylene and isobutane exploded at Phillips 66 plant, killing 23 and injuring 132.

1990 Channelview, Tex.
Wastewater tank at Arco exploded, killing 17 and charring an area the size of a city block.

1990 Cincinnati, Ohio
BASF resins plant explosion left one dead, 71 injured.

1991 Charleston, S.C.
Albright & Wilson Americas phosphorus chemicals plant explosion killed six, injured 33.

1991 Port Lavaca, Tex.
Blast at ethylene oxide unit in Union Carbide's Seadrift plant killed one, injured 19.

1991 Sterlington, La.
Eight deaths, 128 injuries from explosion and fire at IMC Fertilizer facility.

1991 Corpus Christi, Tex.
Hydrofluoric acid vapors at Kerr-McGee plant killed two workers.

periodically reviewed for conformance. The code identifies areas in which companies can improve their safety performance, from process design through operation and routine maintenance.

Many in the industry say the Responsible Care philosophy has become the key to survival in today's tough economic and regulatory climate. And many are working to implement comprehensive management systems that address Responsible Care, the OSHA rule, the anticipated EPA rule, and quality management goals simultaneously.

Assessing how much progress actually has been made toward improving process safety in general, and implementing the Responsible Care Process Safety Code in particular, is not an easy task. Statistics collected by government agencies on such indicators as injury rates and fatalities are only indirect and rather imperfect measures of safety in the chemical industry. Some believe the statistics may obfuscate more than elucidate the industry's track record. Responsible Care's self-evaluation scheme has been criticized for lacking a means of independent, external validation, leading some to dismiss the entire program as a "public relations folly."

While government agencies and other groups such as CMA struggle with improving the measurement tools used to track and evaluate safety, evidence is mounting that recent progress toward implementing the Process Safety Code is more than just hype.

Nonetheless, the industry has many challenges to tackle. Because of OSHA's PSM standard, the cost of compliance is already high; the new EPA rule will certainly raise the cost higher still and the effect of increased regulations on small businesses remains to be seen. Many smaller operations are banding together in networks, sharing resources, ideas, and personnel in an effort to cope.

Meanwhile, companies are examining how to design safety features into plants at the outset, rather than adding them on after the fact, much the same way companies are looking to prevent pollution by turning to environmentally benign syntheses and processes. Another focus of attention is designing management systems capable of ensuring that safety standards are met every day, not just during periodic snapshots at audit time. Part of the solution will be to get a better handle on the causes of human error. And continuing to improve communications with the public, especially with the EPA risk management rule looming ahead, seems to be on nearly everyone's mind.

Vulcan's plant at Geismar, La., lights up night sky.

Rules of the road

It's hard to talk about implementing the Responsible Care Process Safety Code without mentioning in the same breath the OSHA and proposed EPA rules. That's because many companies are leveraging their efforts by adopting a single, unified approach to managing process safety, product quality, and environmental protection. "There's a synergy between the Responsible Care codes, the OSHA standard, the EPA regulations, and quality programs such as ISO 9000," notes Irene L. Jones, coordinator of health and safety at Texaco Chemical in Houston.

DuPont, for example, has written a corporate guideline for process safety management that embraces Responsible Care codes, the OSHA and proposed EPA rules, guidelines of the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers (AIChE), and quality management principles. Explains Arthur F. Burk, senior safety fellow at DuPont: "It's the way we implement the Responsible Care code."

Ray E. Olsen, chief safety engineer at Exxon Chemical, Baytown, Tex., says Exxon is "fully committed to implementing the code on a worldwide basis under a single management system." Many companies observe that a single system creates efficiencies and helps save precious time and resources.

"With so many activities going on in the chemical industry—downsizing, reengineering of plants, quality programs, and implementing the process safety standards—companies' resources are stretched tight," says Winfield S. Person, director of regulatory affairs at Henkel, Gulf Mills, Pa. "It's a matter of how much you can do with finite resources. The amount of work that the regulatory agencies are putting on industry is almost an overburden."

Many companies have been working actively to anticipate the new rules of the road. "Early on, we tried to develop a set of division guidelines that address both the OSHA rule and the Responsible Care Process Safety Code simultaneously," says Bradford T. Clement, division health and safety supervisor at Vulcan Chemicals in Birmingham, Ala.

Team conducts safety audit at Dow Chemical.

Process hazard analysis is costly and painstaking task

The Occupational Safety & Health Administration standard on process safety management and the proposed Environmental Protection Agency risk management rule require many companies to carry out some form of process hazard analysis. It is estimated that as many as 140,000 plant sites in the U.S. will conduct one or more of these analyses by 1997.

The Hazard & Operability (Hazop) study is one of many methods used to systematically review the design and operation of a facility to identify hazards. A study team is assembled, typically consisting of process and control engineers and operations, safety, and maintenance representatives. The team identifies all potential deviations from normal safe operation that might lead to any safety hazard or operating problems.

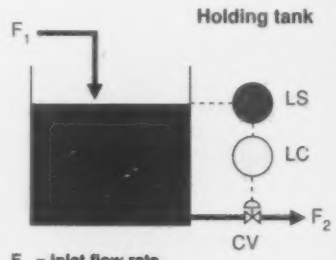
Before a Hazop study begins, documentation on everything from piping and instrumentation diagrams to sequence and interlock descriptions must be updated and verified.

During the Hazop study, one segment of a system is analyzed at a time. The team applies a set of guide words such as "more" or "less" to process parameters like "temperature" or "flow rate." The guide words help team members envision potential effects when off-normal conditions occur. Deviations and their hazardous or significant consequences are recorded in a log sheet, along with recommendations on how to prevent the event or improve safety. The team continues to review the process, one segment at a time, until the entire system is finished.

A simple example to illustrate the Hazop methodology was described by Sanjeev Mohindra and Thomas C. McKelvey of DNV Technica Inc., Columbus, Ohio, at a recent meeting of the American Institute of Chemical Engineers (AIChE). The example involves a holding tank with inlet flow F1 and outlet flow F2. The liquid level in the tank is monitored by a level sensor and is maintained by controlling

Hazop guide words and their definitions

Word	Definitions and examples
No/not	Complete negation of the design intent; no flow in a pipe.
More/less	Quantitative increase/decrease of process variable such as flow rate, temperature.
As well as	All design intentions are fulfilled and something happens in addition.
Part of	Only part of intention is fulfilled; batch reactor is only partly cooled, leading to runaway reaction.
Reverse	Logical opposite of design intention; reverse flow of material, electrical current, control signal, chemical reaction (that is, decomposition).
Other than	Something completely different from intention; tank car of acid is unloaded into caustic storage tank.



F_1 = Inlet flow rate
F_2 = Outlet flow rate
LS = Level sensor
LC = Level controller
CV = Control valve

"Safety has always been a strong focus in the company, but the efforts to formalize and extensively document procedures are new as a result of the OSHA rule and Responsible Care."

DuPont's Burk sees the Responsible Care code and the new government regulations as complementary. "Not only must companies comply with the regulations, but the Responsible Care code urges companies to go beyond and to show continuous improvements," he notes.

Vincent E. Boyen, director of safety and health at Mallinckrodt, St. Louis, agrees. "While there is some overlap between the code and the OSHA rule," he points out, "the Responsible Care code is not chemical specific; it emphasizes the management leadership and personnel issues perhaps more."

So whereas Responsible Care provides a guiding philosophy of continuous improvement in process safety, the OSHA rule outlines specific requirements that employers must meet. The OSHA rule applies to facilities handling any of more than 130 listed toxic chemicals above a threshold amount, or to those that contain more than 10,000 lb of flammable chemicals. Specifically, employers must:

- Develop and maintain written safety information.
- Perform a workplace hazard assessment, including potential sources of accidental releases.
- Consult with employees in carrying out hazard assessments and accident prevention plans.
- Establish a system to respond to hazard assessment findings.
- Periodically review the hazard assessment and response system.
- Develop written procedures for safe operation of processes.
- Provide information and training to employees in those procedures.
- Ensure that contract employees receive appropriate information and training.
- Train employees and contract employees in emergency response procedures.
- Establish a quality assurance program to ensure that equipment is fabricated and installed in a manner consistent with design specifications.
- Establish maintenance systems to ensure ongoing mechanical integrity.
- Conduct pre-startup safety reviews of all equipment.
- Establish procedures to manage change.

Excerpt of Hazop log sheet for holding tank

Guideword	Cause	Consequence	Safeguard	Recommendations to improve safety
No flow	1. Tank empty 2. Line 2 plugged 3. Line 2 rupture 4. Control valve CV fails closed 5. Controller LC failure causes valve to close 6. Level sensor LS reads low 7. Error in signal fed to controller LC 8. Incorrect level set point causes valve CV to close	Operational problems Level in tank increases		Install flow meters on lines 1 and 2
Less level	1. Flow F_1 less than normal 2. Flow F_2 more than normal 3. Leak in tank 4. Incorrect level set point	Outflow reduced		
More level	1. Outlet of tank blocked 2. Inflow to tank greater than normal 3. Outflow from tank less than normal 4. Incorrect level set point	Potential for overflow of the tank	High-level alarm will alert operators to the problem	Install redundant high-level alarm as backup

outflow through a valve. Guide words for this process in the Hazop study would include no flow, less flow, more flow, reverse flow, less level, and more level.

For each guide word, team members would enter potential causes and consequences of the condition into the log sheet. For example, "more level" might be caused by the tank outlet being blocked, potentially causing a tank overflow. Process improvements suggested by the team—for example, installing a backup high-level alarm in the tank—are also entered into the Hazop log sheet.

Now imagine a large, complex chemical plant, and the time and effort required to conduct a Hazop study. "At Monsanto, a typical Hazop [study] of a large process system will take many weeks to complete," according to Monsanto senior fellow Raymond A. Freeman of the company's engineering department in St. Louis. The study team will meet three or four times per week for up to six hours at a stretch. Because Hazop studies are so time-consuming and labor-intensive, Freeman and his coworkers have developed an expert system that can help budget time and resources for the task.

Freeman also is working to build safety into the process at the design stage, as a new process comes out of the R&D lab and before it is scaled up. A new technique, called interactive matrix review, brings the chemist, safety engineer, and lead process engineer together in a systematic study to anticipate and prevent potential hazards associated with a new process.

Hazop studies and interactive matrix reviews are but two of a wide range of techniques for process hazard analysis, many of them described in a guidebook, "Guidelines for Hazard Evaluation Procedures," published by AIChE's Center for Chemical Process Safety.

• Investigate every incident that results in or could have resulted in a major accident in the workplace.

One of the most labor-intensive and time-consuming requirements of the new OSHA rule is preparing for and carrying out a hazard analysis—a systematic procedure to identify, evaluate, and control hazards in industrial processes. The Hazard & Operability (Hazop) study is one of many procedures used for this purpose.

In the Hazop method, a study team is assembled, typically consisting of process and control engineers and operations, safety, and maintenance representatives. The team identifies all potential deviations from normal safe operation that might lead to any safety hazard or operating problems and recommends improvements to the process.

Before a Hazop study can even begin, however, documentation on everything from piping and instrumentation diagrams to sequence and interlock descriptions must be updated and verified. Documentation must include every valve, sensor, and pipe in the system. "For a complex facility, it is not unusual to spend several man-months and more than $100,000 to update and verify documentation prior to a Hazop study," says Raymond A. Freeman, senior fellow in the engineering department of Monsanto in St. Louis.

DuPont's Burk observes that the work doesn't stop there. "It may take hundreds of man-hours to complete a hazard analysis for one process at a plant, anywhere from 200 to 800 man-hours is not uncommon. Our largest sites may have 30 to 40 regulated substances, many of them in more than one process."

But like the adage, "no pain, no gain," many acknowledge the benefits of satisfying the new standards—even companies like DuPont that have been heavily committed to safety all along. "The new OSHA rule helped all of our sites to focus on improving the quality of our implementation of the process safety management standard—things like improving documentation, training, and understanding at all levels about process safety," says Burk.

The cost of the new safety standards may be high, but Vulcan's Clement says the company "expects to receive benefits in terms of even safer and more reliable plants and equipment." Several years ago, recognizing what would be required in the future, Vulcan launched a major effort to update process flow diagrams and documentation, says Clement. Initiated four years ago, the effort is now paying off in terms of implementing the new safety codes.

Robert W. Ormsby, principal engineering associate in the

Designing instrumentation with safety in mind is goal at Henkel.

corporate safety department of Air Products & Chemicals, Allentown, Pa., cites a similar experience: "Process safety has been an important part of the culture at Air Products. Back in the mid-1970s, the company committed to being a leader in safety. Between 1978 and 1992, Air Products had a threefold reduction in recordables and a fivefold reduction in lost-time injuries as a result of our attention to safety."

Recently, the company's plant in Pasadena, Tex., received an award for successfully managing safety during the construction of a new 75 million-lb-per-year polyvinyl alcohol plant, completing more than 1.1 million worker hours with zero lost-workday cases and only six recordable injuries.

Ormsby adds, "The company embarked on a program to educate scientists and engineers in process hazard analysis. Some 2,600 people in the company have received training in those techniques. So when the Responsible Care Process Safety Code came out in 1990, the company had a solid approach to process safety management already in place."

A process hazard analysis is also one element of the proposed risk management program recently released by EPA. Ormsby observes that "the proposed EPA plan extends the spirit of the OSHA standard beyond the fence line, and many aspects of the management system aimed at meeting the OSHA requirements should be transferrable to the risk management rule."

The EPA rule would require facilities to:

- Develop and implement a risk management program, including a hazard assessment, prevention program, and emergency response program. The hazard assessment would include off-site consequence analysis, including the worst case scenario, and a five-year accident history. The prevention program would consist of a process hazard analysis and other elements similar to the OSHA rule.
- Develop and submit to the Chemical Safety & Hazard Investigation Board, along with local emergency planning committees and other local bodies, a risk management plan that would summarize the off-site consequence analysis; list the major hazards and steps being taken to address them; and provide a five-year accident history, a description of the emergency response program, and a description of the facility's safety management system.

Outlined in the proposed EPA rule are some of the similarities and differences between the risk management plan and the OSHA standard. Obviously, OSHA's focus is on workplace impacts, whereas EPA's focus is on off-site consequences, reflecting the different statutory mandates of the two programs. The main differences are the off-site consequence analysis, the five-year history, and public disclosure of the plan. And although the lists of regulated substances are similar but not identical, EPA says, "The elements and language of EPA's proposed ... program are, to the maximum extent possible, identical to the parallel elements in OSHA's process safety management standard."

EPA estimates that more than 140,000 facilities would be affected by the proposed rule, of which 87,800 would also be covered by the OSHA rule. "The total universe of covered facilities includes 22,935 manufacturers; ... 3,360

Ormsby (left): safety is paying off. Person: committed to the code

Community advisory groups help Responsible Care come alive

Diane B. Sheridan, a member of the Chemical Manufacturers Association's Public Advisory Panel, is actively involved with several local groups working to facilitate community-industry communication.

Sheridan gives examples of the impact that community advisory groups can have on:

ACCOUNTABILITY

"One of the biggest changes a community advisory panel makes in a plant is in terms of accountability. Having to report releases, whether planned or accidental, having to respond to concerns and complaints, having to justify not doing something the community expected during an emergency—all of these are done face-to-face with people the plant manager is going to see again and again.

"The public gains a face in a community advisory panel, and that makes the plant manager accountable in a different way than ever before. In time, the plant management and workers come to ask themselves 'What would the public think?' while going about their daily activities, thereby bringing public concerns into the daily operations in a subtle way."

WARNING SYSTEMS

"While some plants have had emergency warning systems in place, others were spurred to make them a reality by input from their community advisory groups":

• Pasadena Citizens' Advisory Council urged all plants in its area to chip in to purchase a siren system and lobbied in support of a request to the city to set up and maintain a warning system.

Sheridan: facilitating communication

• The Community Advisory Panel to Lyondell and Arco urged installation of a warning system and outlined a program to ensure that people know about its existence and what to do if the sirens sound. In addition, they asked for use of a radio channel to notify the community of noticeable non-emergency events such as flares, odors, noises, and construction. This is in addition to more frequent use of the Community Awareness & Emergency Response hotline and local media to announce such activities.

• After fires at two plants lit up the night sky in 1992, the Texas City/LaMarque Community Advisory Panel demanded that plant managers as a group work with the cities to improve communications when there is not an emergency but it looks to nearby residents like there is one. The panel offered dozens of ideas for doing so. The city found that the local radio station was glad to publicize activities ranging from flares and odors to drills and pipeline flaring.

EMISSIONS REDUCTIONS

"When panels decide which chemicals concern them most, plants learn either directly or by inference where to focus reduction efforts."

• Vulcan Community Involvement Group's dogged dialogue about the need for emissions reduction and the community's concerns about deep-well disposal have been acknowledged by the company as the impetus for a variety of emissions reduction projects.

• An odor that caught the attention of many people last spring was discussed at a Texas City/LaMarque panel meeting. The investigation undertaken by the plants led one of them to identify the source and to accelerate plans to repair and replace equipment in order to reduce the possibility of a reoccurrence.

PLANT TOURS

"Plant tours are popular but it can be a challenge to make them meaningful for the public."

• Vulcan Community Involvement Group toured a new unit under con-

private utilities (electric and gas utilities, drinking water systems, and [water] treatment works); 33,250 public drinking water and treatment works; 50,000 cold storage facilities; 9,460 wholesalers; 20,000 propane retailers; and 1,240 service industry facilities," according to the proposed rule.

EPA further estimates the first-year cost of the proposed rule would be $503 million and estimates a saving in terms of environmental damage, human impacts, and response actions totaling $890 million in the first year.

The agency will hold three public hearings in the coming year to receive feedback about the proposed rule, the first of which will be in Washington, D.C., on Nov. 30. Some of the discussion will no doubt center on the definitions of worst case scenario. The proposed rule defines "worst case release" as "the instantaneous loss of all of the regulated substance in a process, with failure of all mitigation systems (active and passive)."

Consequence analysis of a worst case release would be required to estimate the possible rate and duration of release, quantity released, and the distances in any direction that the substance could travel before it dispersed enough to no longer pose a hazard, under average as well as worst case weather conditions. Industry may have some qualms about this aspect of the proposed rule. Ormsby speculates that "the industry will have some challenges to explain the calculations about worst case events to the public."

Good things take time

Although commitment to the Responsible Care philosophy appears to be high, actual progress toward implementing the Process Safety Code seems to lag.

At Henkel, "it's been slower than we wanted it to be," says Person. "We have a strong belief in the Responsible Care initiative. We endorse it and are committed to complying with the codes." Responsible Care activities at Henkel are managed at the vice president level through a team of representatives from each of five operating divisions.

Pasadena citizens' council and industry liaisons study health effects of listed chemicals.

struction almost one-on-one with the plant personnel who will work at that unit. The one-on-one method ... let them get into a lot more detail than often occurs with group tours.

- Pasadena Citizens' Advisory Council, which includes several educators, asked the plants to set up in-service training for science teachers. Visits focused on lab safety, including handling of old chemicals and fighting of small fires.
- Two panels have taken tours related to detecting fugitive emissions. The Texas City/LaMarque panel saw a laser device detect emissions invisible to the naked eye. The device is being developed to help control emissions of specific chemicals.

COMMUNICATIONS

"Every panel struggles with getting information out to the community about its existence and purposes. Communicating about what they learn is a challenge for panels because they would like more people to know what they now know, but they don't want to be seen as an industry cheerleader or spokesman."

- The Deer Park Community Advisory Council gained the support of the local newspaper for publication of a page of industry-related news on expansions, noticeable events, and releases.

Companies that sponsor the community advisory groups referenced by Sheridan include:

Community Advisory Panel to Lyondell and Arco, Channelview, Tex., on north side of Houston ship channel: Arco Chemical, Lyondell Petrochemical.

Deer Park Community Advisory Council, Deer Park, Tex.: Geon, Hampshire Chemicals, Intercontinental Terminals, Lubrizol, Occidental Chemical, Paktank, Rohm and Haas Texas, Rollins Environmental Services, Shell Deer Park Manufacturing Complex.

Pasadena Citizens' Advisory Council, Pasadena, Tex., formed by members of the East Harris County Manufacturers Association Pasadena Outreach Group, including some non-CMA members (six plants rotate as liaisons): AES Deepwater, Air Products, Aristech, Crown Central Petroleum, Enron, Ethyl, Georgia Gulf, Gulf Coast Waste Disposal Authority, Houston Lighting & Power, ICI Americas, Kaneka Texas, Kerley AG Products, Lyondell-Citgo Refinery, Mobil Mining & Minerals, Occidental Chemical, Oxy Petrochemical, Phillips, Safety Kleen, Simpson Pasadena Paper.

Texas City/LaMarque Community Advisory Panel, Texas City, Tex.: Amoco Chemical, Amoco Oil, ISP, Marathon Refinery, Phibro Energy USA, Sterling Chemicals, Union Carbide.

Vulcan Community Advisory Group, Wichita, Kan.: Vulcan Chemicals.

The company's 22 plants vary in their implementation stage, like most other companies in the industry. The pace varies and it doesn't happen overnight, Person says, adding that the company's incident rate is close to the average for its cohort of midsized CMA companies, but its goal is to do better.

CMA member companies conduct an annual self-evaluation of the code of management practices, including those dealing with process safety. The six stages of implementation of the management practices under the Responsible Care code, from lowest to highest, are 1—no action; 2—evaluating existing practices; 3—developing plan to implement management practice under Responsible Care code; 4—implementing plan; 5—management practice in place; and 6—reassessing management practice implementation.

Even companies that have been making safety a priority for many years are struggling to make faster progress toward implementing the Process Safety Code. John W. Oldner, corporate director for safety, loss prevention, and security at Dow Chemical in Midland, Mich., points out that "Dow's been actively working on safety for decades, and we're not there yet." The company average for sites in the U.S. is shy of level 5—"somewhere around 4.7," he says. That's an average based on more than 30 sites, but the sites vary considerably in size and complexity.

In Freeport, Tex., for instance, one Dow site has 80 plants inside the fence, but only one plant is sampled in calculating the company's average implementation level. Other, smaller sites, which are not as far along in implementation of the code, tend to bring down the overall average. But Oldner emphasizes that given finite resources, the company has to allocate them where they'll do the most good.

Person says that Henkel has developed a "tough scale" for measuring performance against milestones that must be met before a plant can proceed to the next level of code implementation. "The process is slow because we are accurate in measuring where we stand. This system of requirements is done for all of the Responsible Care codes," he explains.

Vulcan Chemicals' Wichita, Kan., plant (left). Fish: safety record better than CMA average

Henkel's plant in Charlotte, N.C., employs nearly 200 people, and makes specialty products for the paper, textile, coatings, and ink industries. Safety manager Frank Calloway notes that implementing the Process Safety Code is especially time-consuming for older plants, which require a lot of effort to get old documentation in order.

Calloway says the company has completed hazard reviews there, as well as procedures for incident investigation, management of change, and contractor programs, and has hard-wired the redundancy and backups to improve safety.

The human element is a key part of Henkel's program. "It's critical to spend time training plant operators," Calloway says. "Early buy-in on the part of these people is essential. Spending time up front with them will smooth implementation of the code. You need to build in performance goals for process safety for operations personnel, just like any other performance goals."

Calloway observes that a large part of process control is people control. "We spend a lot of time looking at the causes of human errors, and making sure that things like instrumentation displays and alarm locations are optimally designed with safety in mind. The older processes tend to have less instrumentation and are more labor-intensive. You really have to scrutinize them for potential causes of human error," he says.

The Charlotte facility has a number of batch reactors that are used for different reactions at different times. "Multiple-use vessels create different kinds of risks for each type of reaction. It means our Hazop studies are more complicated—we have to do a new study for each type of reaction, and the reaction mixtures tend to be more complex," Calloway observes.

"The record keeping and documentation can really swamp you," he says, but he points out that there are many advantages to the management-of-change element of the code that offset the paperwork burden: "The side-benefits are that it really makes you look before you leap. And it's a valuable tool for evaluating how a system has evolved over time, giving you a historical record of what changes were made and when, and how the various changes might have combined to produce new effects."

Henkel has upgraded the ethoxylation unit at the Charlotte facility. A Hazop study of the unit helped operators to better understand the process and new procedures before their final operation training, according to unit operator Ron Spencer.

Following completion of the upgrade, plant personnel carried out a pre-startup safety review, updated the emergency response plan, and provided information on the unit to local emergency officials. A comprehensive operator certification training program has now been implemented for all manufacturing personnel at the site. And the management-of-change system has been applied to the entire location to ensure that changes in processes are safe for all production units, say company officials.

George L. Fish, Vulcan Chemicals vice president for R&D, engineering, and environmental health and safety, is the Responsible Care coordinator for that company. He says Vulcan tracks implementation of all 22 management practices and computes an overall average, which currently is just below stage 4 (implementing the code).

Fish says the company's track record on safety is "better than the CMA average." Indeed, one Vulcan facility, the chlor-alkali plant at Port Edwards, Wis., was cited in August for a record 25 years of operation without a lost-workday accident.

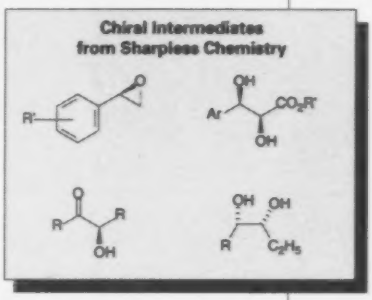
William G. McGlasson, director of environmental services at Olin Chemicals Division in Charleston, Tenn., reports that Responsible Care is a "far-reaching initiative that extends throughout the entire organization in [the] chemicals division." He says it combines existing programs in safety, health, and the environment, and builds upon the safety program instituted in the 1960s.

"Our current safety records speak for themselves," says McGlasson. "Our monthly recordable incidents from December 1990 to May 1993 continue to show positive reductions," dropping from over 4.4 to 2.7 during that period. McGlasson further reports that the level of implementation of the Responsible Care Process Safety Code has increased

NEW

Sharpless Chiral Dihydroxylation at the 4,000 L Scale

Enantiomerically pure chemicals are now available in bulk using the Sharpless Asymmetric Dihydroxylation (ADH) technology.



(R)- and (S)-styrene oxides, substituted diols, hydroxy acids, and α-hydoxy ketones are economically manufactured using readily available starting materials. The Sharpless ADH manufacturing technology is licensed exclusively by Sepracor.

For more information, contact Sepracor Inc, (800) 752-5277 or (508) 481-6700 ext. 204.

SEPRACOR 33 Locke Drive, Marlborough, MA 01752 U.S.A. FAX: (508) 481-7683

ENANTIOMERICALLY PURE INTERMEDIATES

CIRCLE 13 ON READER SERVICE CARD

Olin's Charleston, Tenn., plant conducted its eighth annual safety drill this year with an exercise that simulated a chlorine pipeline leak. Observers from participating agencies critiqued the drill.

in each of the company's three divisions from January 1992 to April 1993: going from 4.8 to 5.3 in basic chemicals; from 5.0 to 5.2 in performance chemicals; and from 3.7 to 4.7 in Olin Hunt.

Community groups get involved

Part of implementing the Responsible Care Process Safety Code is getting the public involved through local community advisory groups. The community group at Vulcan's Wichita, Kan., facility seems to be one of the most extensively involved in plant operations anywhere. Gene Meyer, environmental, health, and safety manager at the plant, tells C&EN that representatives from the company's community group have even been involved in a Hazop study.

It all started in the group's monthly community meetings, where Vulcan representatives discussed the company's plans to build a sodium chlorite plant and described the Hazop study that would be done in the course of preparations. The community involvement group members wanted to understand the Hazop process better, so several attended sessions of the two- to three-week-long study. After the Hazop was completed, the company explained to the group how outcomes of the study resulted in safety improvements.

George Potts, biologist, environmental consultant, and former faculty member at nearby Friends University, participated in the Hazop study. Potts, a community involvement group member for more than four years, sat in on

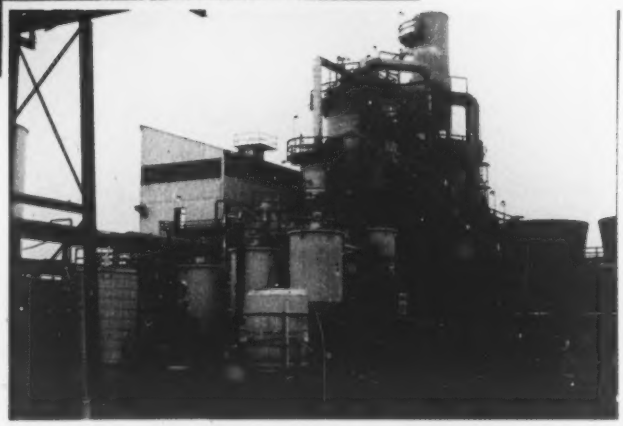
INFORMEX 94

"The Only Custom Chemical Trade Show."

February 7-9

New Orleans, Louisiana

Call (202) 659-0060 for more information.



Sims (above): setting priorities, networking are key for small business. Weyerhaeuser's chlor-alkali facility at Longview, Wash.

about two hours of the Hazop study. In just that short time, he says, two or three items came up that resulted in a change in the way things would be run—and that was only a small fraction of the entire study. Potts believes a Hazop analysis can have a significant impact on plant safety.

Anneke Allen, associate professor of chemistry at Wichita State University, also attended portions of the Hazop study. She says, "It's been a good experience. Vulcan's efforts to clean up the facility have been impressive. The Hazop process worked out well."

Air Products has set up community advisory panels at 10 of its 15 chemical manufacturing sites. One of its most active groups is associated with the company's Escambia Plant in Pace, Fla., near Pensacola. The facility has seven plants on a total of 1,500 acres, of which 500 acres are industrialized, 100 acres are an ecological sanctuary, and 900 acres are an undeveloped buffer zone.

Richard H. Sroufe, environmental superintendent at the Escambia plant, describes activities of the panel that led to the formation of a telephone alert system. Paid for by seven industries in the region, the system is countywide and now can be used even for natural disasters. It was used in two recent events, a flood and a natural gas leak, according to Sroufe. Emergency response plans may call for people either to evacuate or to take shelter where they currently are. Because many people didn't know the proper procedures, the panel developed a training video that is now shown at schools and to civic groups.

Sroufe has worked at the plant for 19 years. Over the past few years, he points out, a much more open relationship with the community has evolved. "It used to be that people didn't know anything about what's happening on the site," he says. "Today, if someone asks a question about the plant, we invite them in. There are tours by the public of the sanctuary grounds. The way we relate to the community has changed."

The opportunity to meet with community members is an important element of the Responsible Care code to Jones at Texaco Chemical. "We can't do enough of this," she stresses.

Jones adds that the new process safety codes have provided incentive for companies to work together more than ever before to ensure safety standards are met. "Openness is more a part of our business now than it was in the past," she observes. For example, in the Jefferson County area of Port Arthur/Port Neches, Tex., some of Texaco's equipment is located on other companies' sites, and vice versa. A couple of years ago, technical and operations people from Texaco met with their counterparts from those companies to identify potential hazards and to establish responsibility for mitigation. "It was a very positive experience," says Jones. "Besides sharing the responsibility, the companies are sharing in the benefits of safety activities."

Small business bears up

Under the new rules of the road, many small businesses are now or will be establishing process safety management programs. With limited technical and financial resources to bring to bear on the problem, however, many small firms are struggling to cope.

A technically underserved segment of a larger business may find itself in the same boat. For example, large packing houses that handle anhydrous ammonia as a refrigerant may be required to conduct a process hazard analysis but may not have the expertise to do so.

OSHA estimates that small businesses will bear a collective cost of $88.9 million per year during the first five years of the process safety management standard. Yet many believe that the benefits will outweigh the costs in terms of fatalities and injuries avoided. Eric J. Lohry, manager of operations at Nutra-Flo in Sioux City, Iowa, presented a case in point at the summer national meeting of AIChE in Seattle last August.

Lohry points out that the challenges faced by small businesses as they implement process safety management systems are different from those encountered in large firms. "Without multiple layers of management, decisions are often made quicker, making management of change more de-

Nutra-Flo's plant in Sioux City, Iowa. Lohry (right): small business is taxed

manding," he notes. And "the smaller the business, the more hats a given employee may need to wear. For example, a small manufacturing firm may not have a safety specialist on staff, relegating those duties to the plant manager or engineer."

And the corporate culture is different in small firms. "Many small businesses do not have the same emphasis on safety as larger ones," says Lohry, and they "often will not have formal operating procedures and training programs. This will make the documentation, training, and management of change provisions of the [OSHA] rule difficult to achieve." And the overall cost of developing a safety program will be higher as a percentage of profits in a small company, he contends.

On the other hand, small firms may have greater flexi-

From A Continuous Process Second To None.

O-NITROBENZOIC ACID.

Produced by a new world class continuous process based on key technologies and developed exclusively by the Nobel Chemicals team— a leading worldwide supplier of p-Nitrobenzoic acid and m-Nitrobenzoic acid.

Nobel. Pure Performance. Pure Chemistry.

U.S.
Nobel Chemicals, Inc.
1530 Valley Center Parkway
Suite 110
Bethlehem, PA 18017, USA
Phone: (215) 866-4100
Fax: (215) 867-4577

Nobel Chemicals
Nobel Industries Sweden

Nobel Chemicals AB
Fine Chemicals Division
S-691 85 Karlskoga
Sweden
Phone: 46 586 83000
Telefax: 46 586 32147

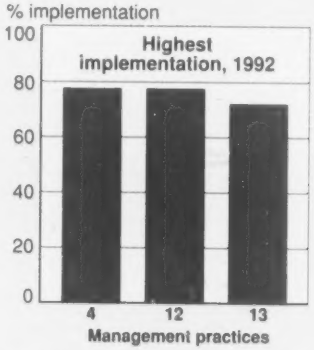
CIRCLE 9 ON READER SERVICE CARD

Progress toward Process Safety Code is higher for some management practices than for others

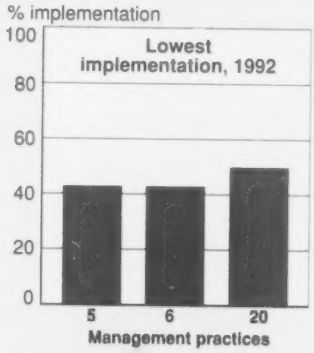
Member companies of the Chemical Manufacturers Association (CMA) conduct an annual self-evaluation of the codes of management practices, including the 22 practices dealing with process safety. The self-evaluations help members identify their strengths and weaknesses in carrying out Responsible Care. They also help CMA to identify areas where assistance for members is needed.

The six stages of implementation of the management practices under the Responsible Care code, from lowest to highest, are as follows: 1—no action; 2—evaluating existing practices; 3—developing plan to implement management practice under Responsible Care code; 4—implementing plan; 5—management practice in place; 6—reassessing management practice implementation.

The charts show the percentage of member companies (more than 150 companies reporting) that are in the final stages (levels 4 to 6) of implementing the process safety management practices. Management practices with the highest and the lowest percentages of companies in the final stages of implementation are shown.



4. Incident investigations—investigating, reporting, and follow-up of each incident
12. Facility design, construction, and maintenance—using sound engineering practices
13. Facility reviews—safety reviews on new/modified facilities during design and before startup



5. Sharing safety knowledge—sharing lessons learned about incidents with others
6. Use of Community Awareness & Emergency Response in design—considering public comments and concerns about process safety systems
20. Documentation of proficiency—demonstrating skill proficiency before work assignment

bility within their workplaces than large ones, and may have the most to gain from compliance. While small businesses account for only about 10% of the total cost of compliance, their share of avoided fatalities may be higher. OSHA estimates that "21% of fatalities avoided and 9% of lost-workday injuries avoided will occur in small establishments."

As an example, Lohry describes the case of his own company, Nutra-Flo, a small chemical manufacturing firm specializing in fluid fertilizers, currently with about 70 employees. The business has been family owned for some 35 years. "The company is typical of many small manufacturers in that there are only two engineers and two chemists on the technical staff," he says. "As would be expected in a small facility, the managers and engineers handle the safety function as well as other functions" in the business. The company uses anhydrous ammonia, phosphoric acid, potassium chloride, and ammonium thiosulfate, among other compounds.

"Safety has always been emphasized strongly by management. Since the 1960s, regular safety meetings were held and training was provided," Lohry says.

But in 1990, a disastrous explosion killed two welders. "In that same year, OSHA printed its preliminary process safety management standard, steering the safety management of the company in a new direction," he says.

The company established a loss control department to handle safety training and auditing and developed the company's first safety manual, as well as systems for incident investigations and preventive maintenance. Hazardous operations were reviewed using AIChE's CCPS guidelines even before the OSHA rule became law. "Without question, the CCPS guidelines were the backbone of the company's process safety management efforts. Prior to these guidelines, a small company with limited resources would be taxed to find acceptable methods and procedures," Lohry emphasizes.

The end result was a dramatically improved safety record, says Lohry. "For the first time since records were kept, the company had no recordable injuries for the year following the implementation of the corporate loss control program. The company has received safety awards and after three years, bottom-line improvements are showing up from lower insurance premiums," he adds.

Some small companies are finding that setting priorities and establishing regional networks can facilitate the implementation of process safety programs in the face of scarce resources.

Jim Sims, plant manager at the Weyerhaeuser chlor-alkali facility in Longview, Wash., stressed at the AIChE meeting last August that "the implementation of Responsible Care at the small manufacturing facility can be accomplished, but the philosophy of the 'critical few' must be followed. A small facility must select the codes that will have the greatest impact." He adds: "If too many tasks are attempted at the same time, then substantial progress is rarely obtained. The 'critical few' for us were CAER, the Process Safety Code, and the Employee Safety & Health Code, because these codes have the greatest daily impact on how we run our facility and how we interact with the community—our employees, their families, and our neighbors."

The Weyerhaeuser chlor-alkali facility, with about 100 employees, manufactures chlorine and other inorganic chemicals. Although it is part of a much larger pulp and paper complex at Longview, Sims' operation was largely on

its own when it came to implementing the Responsible Care codes. "Responsible Care was assigned to a plant employee along with other duties," he says. "Initially, the material coming from CMA was overwhelming—too much, too fast. The coordinator felt swamped." By prioritizing, and with the help of a regional mutual aid network, substantial progress was eventually made. "The network has been extremely valuable in learning what other people are doing, the mistakes, and the successes."

Judith A. Cichowicz, general manager of Northwest Field Services, a Seattle-based hazardous waste management and environmental remediation firm, explains more about the regional network Sims referenced. "In an era of reduced resources, mutual aid serves as a resource enhancement device, permitting you to do more with less by making available an objective peer group," she says.

Cichowicz observes that the economics and geography of the Pacific Northwest region added an impetus to form the network. "The chemical industry is not a major industrial force" in the region, which has a natural-resource-based economy and population centers widely separated by large distances.

A survey sent to plant contacts in Washington, Oregon, and Idaho—identified by means of a CMA database—helped target the topics relating to Responsible Care of highest priority for the mutual aid group. Process safety was second in priority after community advisory panels. At network meetings, attendees shared information about implementing the Process Safety Code, conducting Hazop studies, and communicating about risks.

"Through organization of a simple, quasi-formal network, chemical companies in the Pacific Northwest have moved closer to successful implementation" of the goals of Responsible Care, says Cichowicz. "The approach is inexpensive, cost effective, and transferable to other parts of the U.S.," she observes.

Taking stock of progress

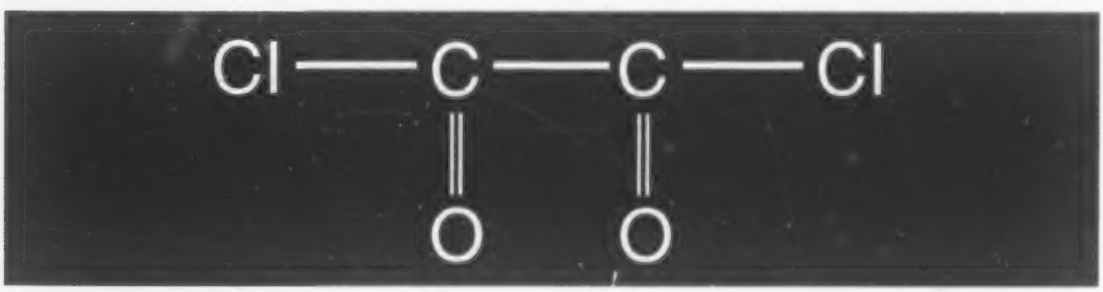
To ensure that Responsible Care codes reflect real public concerns, they were reviewed at every step of the way by a national Public Advisory Panel. Some 15 members from different constituencies and regions have been working to broaden CMA's understanding of public concerns about the use of chemicals in society.

Panel member Press L. Robinson, chemistry professor and associate vice chancellor for academic affairs at Southern University, Baton Rouge, La., believes, "Responsible Care is a good first effort on the part of the chemical industry to change its image and the way it does business."

Robinson says when the Public Advisory Panel was started four years ago, he initially had reservations about being on the panel. "Was this an initiative to make actual changes in industrial practices or just a slick public relations campaign—were we being co-opted?" he asked.

OXALYL CHLORIDE

AN EFFECTIVE COMPLEMENT TO OUR PHOSGENE CHEMISTRY



CHEMILYL, A MEMBER OF THE SNPE GROUP, IS OFFERING INDUSTRIAL QUANTITIES OF OXALYL CHLORIDE WITH A CAPACITY OF SEVERAL HUNDRED MT PER YEAR.

FRANCE : ISOCHEM
Specialty Pharmaceuticals Dept
Phone (33) 1 47 94 97 00 - Fax (33) 1 47 94 68 86

U.S.A. : SNPE North America
Phone (609) 987 94 24 - Fax (609) 987 27 67

GERMANY : SNPE GmbH
Phone (49) 69 72 97 51 - Fax (49) 69 724 08 36

GREAT BRITAIN : SNPE England
Phone (44) 81 649 74 74 - Fax (44) 81 760 04 20

JAPAN : SNPE Japan
Phone (81) 33 433 28 80 - Fax (81) 33 433 66 52

SNPE CHIMIE

CIRCLE 44 ON READER SERVICE CARD

"After a few meetings, I learned that the chemical industry was serious," he says. What convinced him? "Seeing our input actually get incorporated into the codes."

Panel members are donating a considerable amount of time and energy to this service, Robinson says. Members attend five meetings per year, of two to three days duration each. Although travel expenses are paid by CMA, no per diem, stipend, or honorarium is provided.

"I have been surprised that a group so diverse has been able to build consensus on the direction things should go," says Robinson. "Now, our posture is to monitor the implementation of the codes and see to it that genuine changes are made in industrial practices. External validation is extremely important. Self-evaluation by companies is a good start, but it won't convince the public."

What kind of report card would panel members give to the effort? "I'd give them a good C," says Robinson. "It's a great effort so far, but there's a whole lot that needs to be done. It's important to remember, though, that the situation wasn't created overnight, and it won't be solved overnight." He observes that the public tends to think that the chemical industry has deep pockets and has the money and other resources to solve anything. "Not so," Robinson asserts. "Changing the corporate culture is a tall order. From the board room to the shop floor, we're calling on people to understand, accept, and internalize the Responsible Care codes. Though the top levels of management are on board, selling the code to middle management and to the worker on the shop floor is the hardest part of the job."

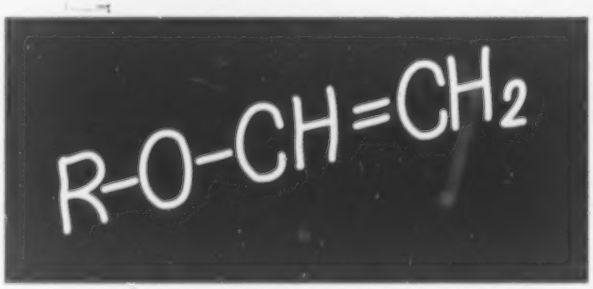
Public advisory panel member Hoyt D. Gardner, physician and former American Medical Association president, says implementation is "proceeding as fast as expected." He was "initially curious as well as suspicious," when he first joined the panel, but now says he's "absolutely convinced that industry is not involved in Responsible Care just for a public relations campaign. The general public knows a public relations gimmick when it sees one. This is a day-in and day-out thing." One factor that convinced him was that panel members were given whatever information and access they asked for at the plants they visited, which included Rohm and Haas in Houston, Monsanto in St. Louis, and Kodak in Buffalo. "They weren't holding anything back," he says.

Panel member Diane B. Sheridan says, "Implementation seems to be moving along, but there is no way of telling for sure since a means of external verification is lacking." Sheridan lives in Taylor Lake Village, Tex., about 1.5 miles from an industrial plant. She says that throughout the region, there are now many community advisory panels; she serves as facilitator for several. Awareness in these communities has increased about health, safety issues, and emergency preparedness, and companies now are doing a better job of sharing information, she says.

Panel member Don Lesh of the Global Tomorrow Institute, Washington, D.C., says he was "very impressed at the results of what has been a careful and conscientious effort by CMA to develop and track each of the Responsible Care codes. It's been pleasing to see that things the panel has discussed get incorporated." But, he says, external verification remains a glint in the eye. And surveys have shown that employees on the shop floor "are not very aware of and/or involved in Responsible Care." Based on plant visits and meetings, the panel has sensed that commitment is

BASF INTERMEDIATES

Vinyl Ethers — the innovative challenge



Because of their high reactivity, vinyl ethers can be used successfully in a variety of syntheses.

Radiation curing systems

Polymer building blocks, diluent and crosslinking monomers.

Comonomer in various polymers

Motor oil additives

Pharmaceutical products

Ion-exchange resins

Flavors and fragrances

Call us!

If you have a project where BASF expertise in vinyl ethers could help you, call Christiane Haller CZN/EC, Tel. 06 21-604 91 74 (Germany) or John Banger, NCI, Tel. 201-316-4006 (USA)

Fax us!

Contact BASF — your direct link to all your vinyl ether needs.
In Europe: Germany
0621-60-22666
In North America: USA
201-402-6275
In Asia: Japan
03-3238-2290

Intermediates

Creative Chemistry for Creative Chemists

BASF

CIRCLE 23 ON READER SERVICE CARD

Injury rates appear higher for smaller chemical firms

Injuries per 100 employees	Company size (employees)							
	1–19	20–49	50–99	100–249	250–499	500–999	1,000–2,499	2,500
1986	6.3	9.5	11.1	8.4	6.6	5.1	3.5	3.1
1987	5.8	9.8	12.2	9.0	6.5	5.7	4.1	3.9
1988	8.1	11.5	11.5	8.3	6.6	5.5	3.7	4.1
1989	6.7	10.4	11.2	8.5	6.9	6.1	3.5	3.7
1990	5.0	11.7	10.6	8.0	6.2	4.9	3.3	3.5
1991	6.9	10.1	9.4	8.2	5.1	5.6	3.5	3.2

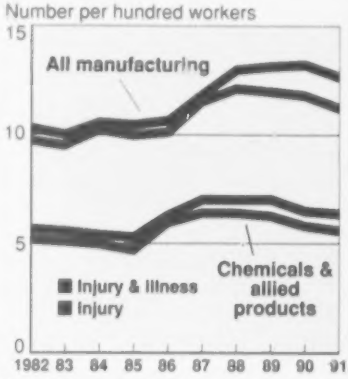
Source: Bureau of Labor Statistics

Fatalities in chemical and allied products industry triggered OSHA inspections

	1992	1991	1990	1989	1988	1987	1986	1985	1984	1983	1982
Number of inspections	23	41	28	33	23	41	30	33	27	37	30
Inspections with citations contested	8	7	8	10	10	12	6	5	6	5	4
Number of fatalities[a]	23	54	34	57	26	44	34	67	29	45	38
Number of violations:											
Willful[b]	13	0	93	3	1	11	1	6	1	6	0
Serious[c]	106	162	147	107	36	86	49	26	40	27	25
Total[d]	160	213	281	155	59	188	93	46	76	39	35

a Does not include data on contractors, and some fatalities may not have been reported. b Serious or nonserious violations for conditions known to exist. c Violations causing or likely to cause death or serious harm, and company knew or could have known of hazard. d Includes willful, repeat, serious, unclassified, other, and failure-to-abate violations. **Source:** Occupational Safety & Health Administration

Worker injury, illness rates head down



Note: Occupational injury is any injury such as a cut or fracture that results from a work-related event or from a single instantaneous exposure in the work environment. Occupational illness is any abnormal condition or disorder, other than one resulting from an occupational injury, caused by exposure to factors associated with employment, including acute and chronic illness or disease that may be caused by inhalation, absorption, ingestion, or direct contact. **Source:** Bureau of Labor Statistics

evident at chief executive officer and senior management levels, but not on the shop floor. "It's a major challenge for all companies," he adds.

Michael J. Wright, director of the health, safety, and environment department at United Steelworkers of America, Pittsburgh, Pa., believes there is room for improvement in bringing organized labor into the Responsible Care process, and remains skeptical whether CMA will get tough on companies that fail to comply with the code. "The jury is still out on Responsible Care. It depends upon voluntary compliance. How it gets implemented will be the real test." Because the form of implementation is at the discretion of the companies, Wright fears that some companies "may comply with the letter of the code, but not the intent."

Robert Wages, president of the Oil, Chemical & Atomic Workers International Union, Denver, also is skeptical. "I regard Responsible Care as a public relations folly. I've not seen any practical application of it," he says. As for the new OSHA process safety management standard, he is "still searching it out."

Wages believes there has been a lack of real input from the workers on how the process safety management standards are implemented inside the plants. "Industry is relying too much on outside consultants instead of the people inside the plants," he charges. Consultants lack site-specific knowledge, he believes, and bring only textbook knowledge to bear.

Wages fears that reinventing government may end up meaning the fox will guard the hen house: Instead of hiring enough OSHA inspectors, industries will contract out inspections or conduct inspections themselves.

He has more positive words about the increased participation by workers in hazard analyses. But overall, Wages believes that how industry will follow through on implementing the new process management standard in practice remains to be seen. "It's still unfolding," he says.

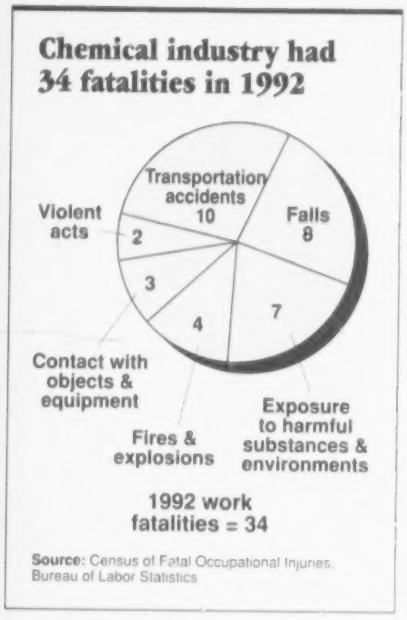
The OSHA rule is a performance-based standard, meaning that it defines what must be done, but not how. Both industry and labor have been uneasy about how OSHA will interpret the rule. In response to threat of a lawsuit, OSHA signed a settlement agreement with labor groups earlier this year that requires certain language relating to the rule to be spelled out in OSHA's next compliance directive, to be published "soon," according to the agency.

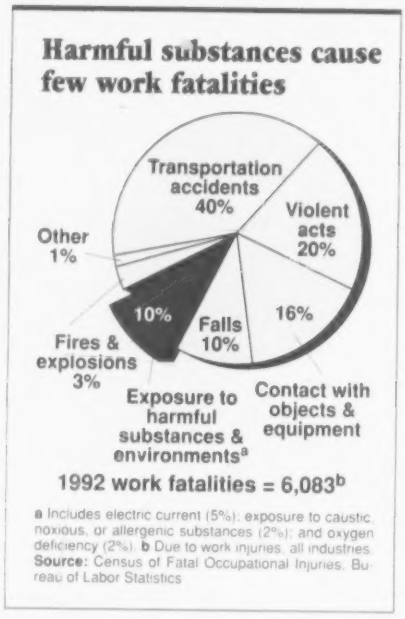
Among other things, the settlement statement specifies that process hazard analysis teams' recommendations are to be implemented unless an employer can document that an alternative will address the concerns at least as effectively and efficiently. Labor groups generally believe that companies should be obligated to implement the recommendations in order to ensure safety for workers. Many in industry, including CMA, have issued statements saying in effect that it is inappropriate to turn recommendations into imperatives, and that many factors must be weighed in addressing safety issues.

Safety report card: U for uncertain

They say the devil is in the details. In this case, it is the lack of detail in available data that bedevils any attempt to track safety in the chemical industry.

Self-evaluations by CMA member companies show that




Harmful substances cause few work fatalities
Transportation accidents 40%
Violent acts 20%
Other 1%
10%
Falls 10%
16%
Fires & explosions 3%
Exposure to harmful substances & environments[a]
Contact with objects & equipment
1992 work fatalities = 6,083[b]
a Includes electric current (5%); exposure to caustic, noxious, or allergenic substances (2%); and oxygen deficiency (2%). b Due to work injuries, all industries.
Source: Census of Fatal Occupational Injuries. Bureau of Labor Statistics

incident investigations, facility design, and safety reviews are the three management practices within the Process Safety Code that have the highest average level of implementation. Lagging farthest behind are the practices relating to sharing safety knowledge and considering public comments and concerns in the design of processes.

But these are averages of averages—and not terribly informative when trying to evaluate how safe the industry is and whether the new rules of the road are making any improvement in chemical process safety.

Injury rates for the chemical and allied products industry appear to be well below the rate for manufacturing as a whole. But those figures, like the data on fatalities collected by OSHA, may be skewed because they do not include contract workers.

Moreover, the number of fatalities in the chemical industry reflected in the OSHA database may also be low because some deaths may not have been reported, and because the database may not have been updated with deaths from cases still classified as open. For example, at the time of this writing, the OSHA data on fatalities presented here do not include deaths from the 1990 Arco Chemical Channelview incident, because the case is not yet closed; and even if they were included, only five of a total of 17 deaths from the incident would appear in this summary for the chemical industry because the other fatalities were contract workers. In short, about all that can be said with certainty is that the figures presented here represent minimum values.

On first glance, injury rates for small to midsized chemical companies seem to be almost double the industry average and nearly three times the rate found in the largest firms, suggesting that smaller companies are perhaps less "safe." But upon further reflection, the significance is unclear. Other factors such as the number of contractors employed, and the number of support, managerial, and other nonplant jobs, may contribute to the difference in rates between small and large firms. The Bureau of Labor Statistics (BLS) is in the process of redesigning its procedures to capture information on occupation type that eventually may help clarify the question.

BLS released its first-ever national census of fatal occupational injuries last month. The census, completed for the year 1992, used multiple sources to identify, verify, and profile fatal work injuries. In contrast to the 23 fatalities in the OSHA database, the BLS census found 34 deaths in the chemical and allied products industry in 1992. Most fatalities were due to transportation accidents and falls. Exposure to harmful substances and environments, and fires and explosions caused the third and fourth largest number of fatalities, respectively.

Injury and fatality rates are only an indirect and somewhat imperfect indica-

OSHA Star: Seal of approval

The Occupational Safety & Health Administration's "good housekeeping seal of approval," the Star certification, has been awarded to 97 sites among 52 companies, of which about 70 sites are chemically related. The Star rating is part of OSHA's Voluntary Protection Program, designed to "recognize and promote effective safety and health management." To be eligible, workplaces must have injury incident and lost-workday injury rates at or below the industry's national average. Companies receiving the Star certification include:

Company	Number of sites
Amoco Foam Products	1
BASF	2
Ciba Chemical	2
Corning	1
Dow Chemical	4
DuPont	3
Exxon	1
GE Plastics	2
Georgia Pacific	2
Hoechst Celanese	2
Huntsman Design	1
IBM	2
Kerr-McGee	4
Lyondell Petrochemical	1
Mobil Chemical	18
Mobil Mining & Minerals	1
Mobil Oil	1
Monsanto Chemical	2
Motorola	2
Ortho Diagnostic Systems	1
OxyChem Petrochemicals	6
Pioneer Chlor Alkali	1
Star Enterprise	1
Texaco	4
Amoco Foam Products	1
BASF	2
U.S. Paint	1
Weyerhaeuser Paper	1

Curriculum development targets safety

One of the newest projects of the Center for Chemical Process Safety (CCPS) of the American Institute of Chemical Engineers is a cooperative effort among universities, industry, and government agencies to develop undergraduate educational materials emphasizing safety, health, and loss prevention.

According to CCPS director Bob G. Perry, some 70 colleges and universities have joined the safety and chemical engineering education program. A set of homework problems has been developed that can be used in undergraduate engineering courses or as class projects. The problems give students an opportunity to apply fundamental engineering principles to such practical examples as storage and handling of hazardous materials, toxicology and industrial hygiene, fire protection, and release mitigation.

CCPS reports that the curriculum materials have been used in nearly one third of the colleges and universities in the U.S. offering chemical engineering training. About 30% of sales of the package have been to industrial organizations.

Perry: emphasizing education

tor of safety in the chemical industry. CMA's proposed Prospect system may offer a more direct measure. According to Donald D. Helin, director of safety, plant operations, and CAER at CMA, the system would require CMA member companies to file annual reports on any fire or explosion causing more than a threshold dollar amount ($10,000 has been proposed) in damage; any reportable chemical release of a substance on CMA's list; and any serious injuries or fatalities. Helin says the data collected under the Prospect system would be establishment-based, so that reports on injuries and fatalities would include all personnel at a site—contract workers as well as employees.

A pilot study of Prospect conducted in several companies helped CMA develop the plan that went before the board last month. Helin says that details on the exact chemicals and thresholds are still being worked out. CMA's goal, he says, is to develop a "meaningful measure that will be credible to the public."

Future prospects

In the longer term, companies seem to be concerned about how to get beyond the safety plateau. "The emphasis at Air Products on prevention of safety problems means that inherent safety is a focus: Safety is designed into the process at the early stages of process development," says Ormsby. "Reducing the inventory of hazardous materials, or even substituting hazardous materials with less hazardous ones—we look at many ways to make the process more inherently safe."

Ormsby says the company also will be giving increasing attention to integrating safety management practices with suppliers and "tollers," or companies that produce materials for Air Products under contract. Ormsby explains that cooperative arrangements relating to hazard analyses and safety reviews are built into the contract, so that Air Products can share its expertise in process safety management and ensure that safety standards are consistent with its own.

Ormsby further points out that a company has to have strong management systems in place that are capable of ensuring that safety standards are met even while weathering changes in business, turnover in leadership, or organizational restructuring.

Bob G. Perry, director of AIChE's Center for Chemical Process Safety, New York City, echoes that theme. "We need better measures of how process safety management is applied on a day-to-day basis and how continuous improvements can be made. Audits are just a snapshot at one point in time. How do we ensure safety standards are met the rest of the time?" he asks.

Perry joined CCPS last March from Union Carbide where he was vice president of manufacturing and engineering. He observes that "there has been a tremendous amount of work to improve the technology needed to improve process safety. Yet the perception may exist that process safety is not improving at the rate people would like it to. Many times, the causes of accidents have less to do with technology and more to do with the failure of management systems to ensure that existing technology and procedures designed to protect safety are efficiently and effectively employed.

"Technology is not enough; you've got to have effective management" to ensure the safety of chemical processes, says Perry. Toward that end, the center has launched a research project aimed at determining how to track and measure the quality of management systems relating to process safety. To begin with, the project is focusing on two elements: management of change, and training. Project personnel will be identifying actual plant sites for closer study.

Another new CCPS initiative is aimed at educating the next generation of chemical engineers in process safety and loss prevention. In the final analysis, eliminating causes of human error and training plant personnel in safe work practices may be a key part of improving safety.

As Mallinckrodt's Boyen concludes, "Safety is not an absolute—it's a relative term. You'll never totally eliminate risk in things—but you do manage risk, and decide what's an appropriate level. You could put in safeguard after safeguard, but still not totally eliminate risk. The reality is, you have to put resources where they're going to do the most good; and you have to train employees to avoid hazards and to work safely." □